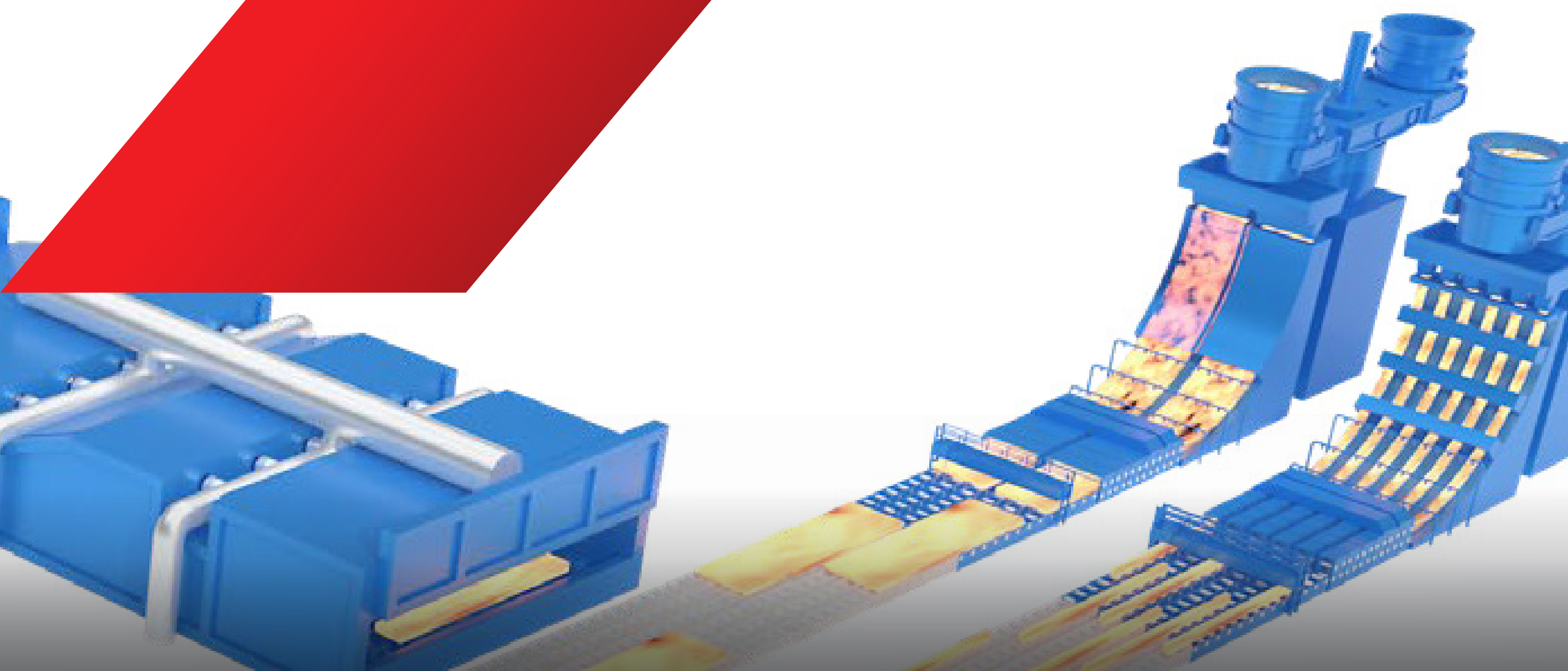
LAND
AMETEK®

APPLICATION NOTE



THE ROLE OF TEMPERATURE MEASUREMENT IN SUSTAINABLE STEELMAKING

The steel industry is responsible for approximately 7% of global manmade CO_2 emissions. Finding a way to meet ongoing demands for the quantity and quality of steel required, while reducing and eventually eliminating carbon emissions, is a major challenge for everyone involved in steel production.

Temperature monitoring solutions can help in the transition to more sustainable methods of steelmaking, supporting decarbonisation in a number of ways. This technology is also suitable for use with a range of fuels, supporting the transition to hydrogen as a carbon-free fuel source.

INTRODUCTION

The global steel industry faces an ongoing decarbonisation challenge, driven by more stringent carbon emission regulations, growing customer demand for carbon-friendly steel products, and increasing investor interest in sustainability.

Many of the world's largest economies have pledged to achieve net zero carbon emissions by 2050, putting extra pressure on steelmakers to to reduce their environmental impact.

According to figures from the World Steel Association, every tonne of steel produced in 2020 led to, on average, the emission of 1.851 tonnes of carbon dioxide (CO_2) into the atmosphere.

In that same year, 1,860 million tonnes of steel were produced, and total direct emissions from the sector were approximately 2.6 billion tonnes, representing between 7% and 9% of global man-made CO_2 emissions.

The cost is not purely environmental; according to a McKinsey and Co report, approximately 14% of global steel companies' potential value is at risk if they are unable to decrease their environmental impact, making decarbonisation a high priority.

There is no single solution to carbon reduction in steelmaking; however, several changes to existing practices can each make a significant contribution to decarbonisation in the industry. Process parameters are changing throughout the industry in a bid to bring down carbon emissions.

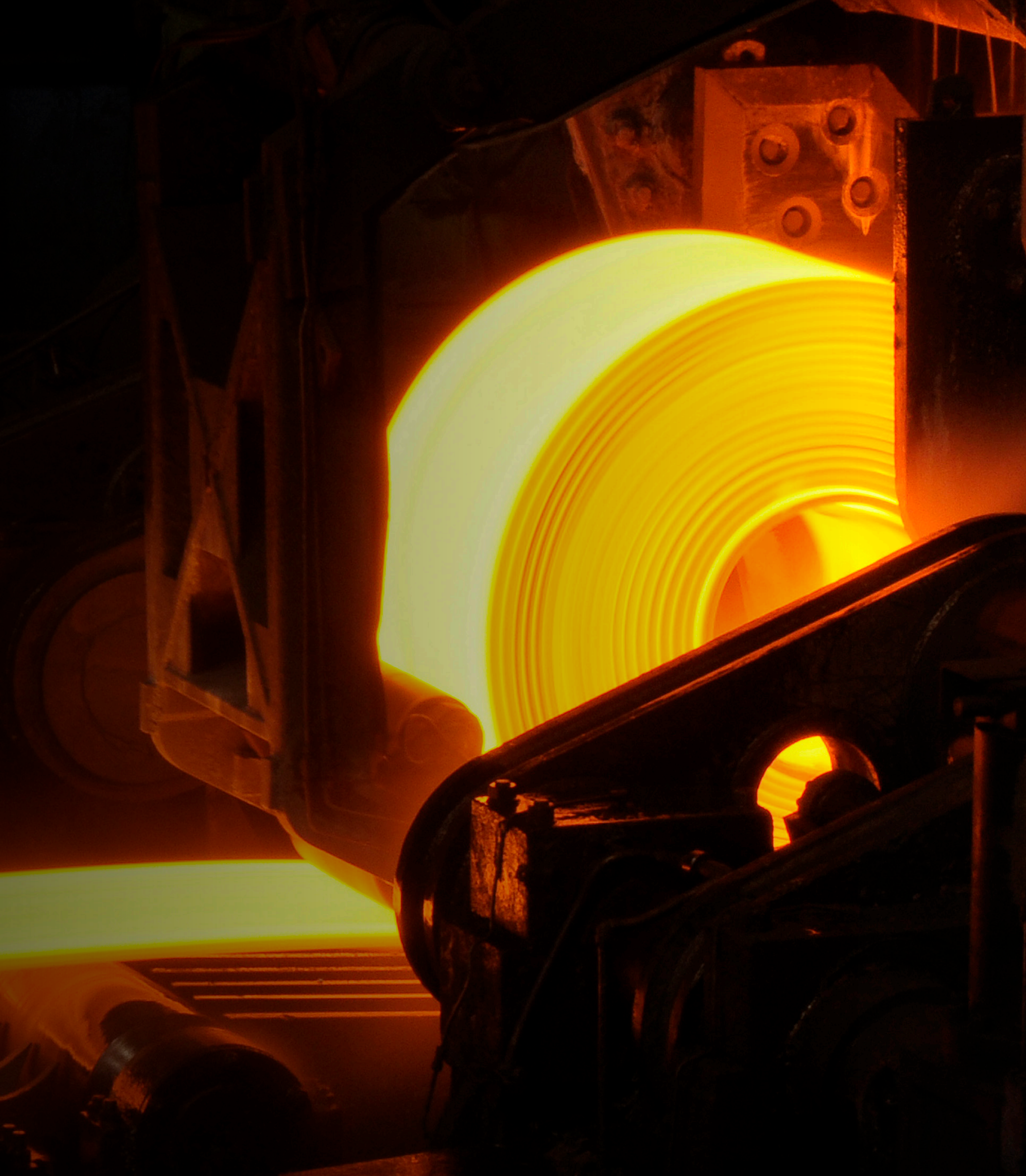
For temperature measurement solution providers, the primary application in this area is slag detection in electric arc furnace (EAF) operations. Using an EAF instead of the traditional furnace can significantly reduce carbon emissions, and monitoring liquid metal in the melting process supports even greater efficiency.

An approach combining scrap, direct iron reduction (DRI), and EAF using hydrogen fuel is currently considered the most viable, long-term solution to achieving carbon-neutral steel production.

Additionally, temperature measurement – using thermal imagers – can support safety by monitoring ladle exteriors to detect hotspots that could indicate the early stages of a damaged or thinning refractory lining. This helps operators to avoid dangerous breakouts of molten metal, which pose a significant risk to personnel and equipment.

A thermal imager-based system can also be used to continuously measure multiple zones in the area of the refractory where the freeboard level appears. An alarm can be triggered when each one is filled, providing an easy and accurate detection of the level of the molten metal, and preventing overfilling, again improving safety.

Using thermal imagers instead of contact-measurement solutions such as dip thermocouples helps support decarbonisation efforts by reducing the use of consumables such as thermocouple tips, and delivers more information to support process efficiency.



ELECTRIC ARC FURNACES

Moving from a basic oxygen furnace (BOF) to an electric arc furnace (EAF) route for steelmaking can make a significant contribution towards decarbonisation in the industry.

In an EAF, steel is produced from recycled scrap and direct-reduced iron (DRI). The need for high-quality scrap may limit the use of EAF and increase costs. However, mixing lower-quality scrap with DRI is a cost-effective option, while DRI alone generates less carbon dioxide than integrated methods. In addition, the EAF can, potentially, be used with hydrogen fuel for nearly emission-free steel production.

The EAF uses vertical graphite electrodes to melt the iron and scrap via an electric current. Metal is added, the lid is closed, and an arc is created between the electrodes.

A huge amount of power is used by the process, so it is often scheduled to operate during times of low energy demand. At this point, limestone flux is added and, after some time, a ladle vessel is positioned underneath before a hole in the base of the furnace opens and the molten steel exits into the ladle. The hole closes when slag is detected or when the ladle is full.

The steelmaking steps for an EAF are:

- **Charging scrap metal, iron, and limestone**
- **Lowering the electrodes, melting the metal with electric current**
- **Oxidation**
- **De-slagging**
- **Adding new fluxes for reducing stage to eliminate sulphur and oxide absorption**
- **Tapping**
- **Lining maintenance to eliminate molten steel breakouts from excessive lining depletion**

Molten steel is tapped at regular intervals. Accurate temperature monitoring ensures steel quality is consistent and improves process efficiency. While it seems that the steps are straightforward, detecting slag and keeping it from degrading the steel is both an art and a science, and the detection methodology has evolved significantly over time.

MONITORING SLAG CARRYOVER IN THE EAF

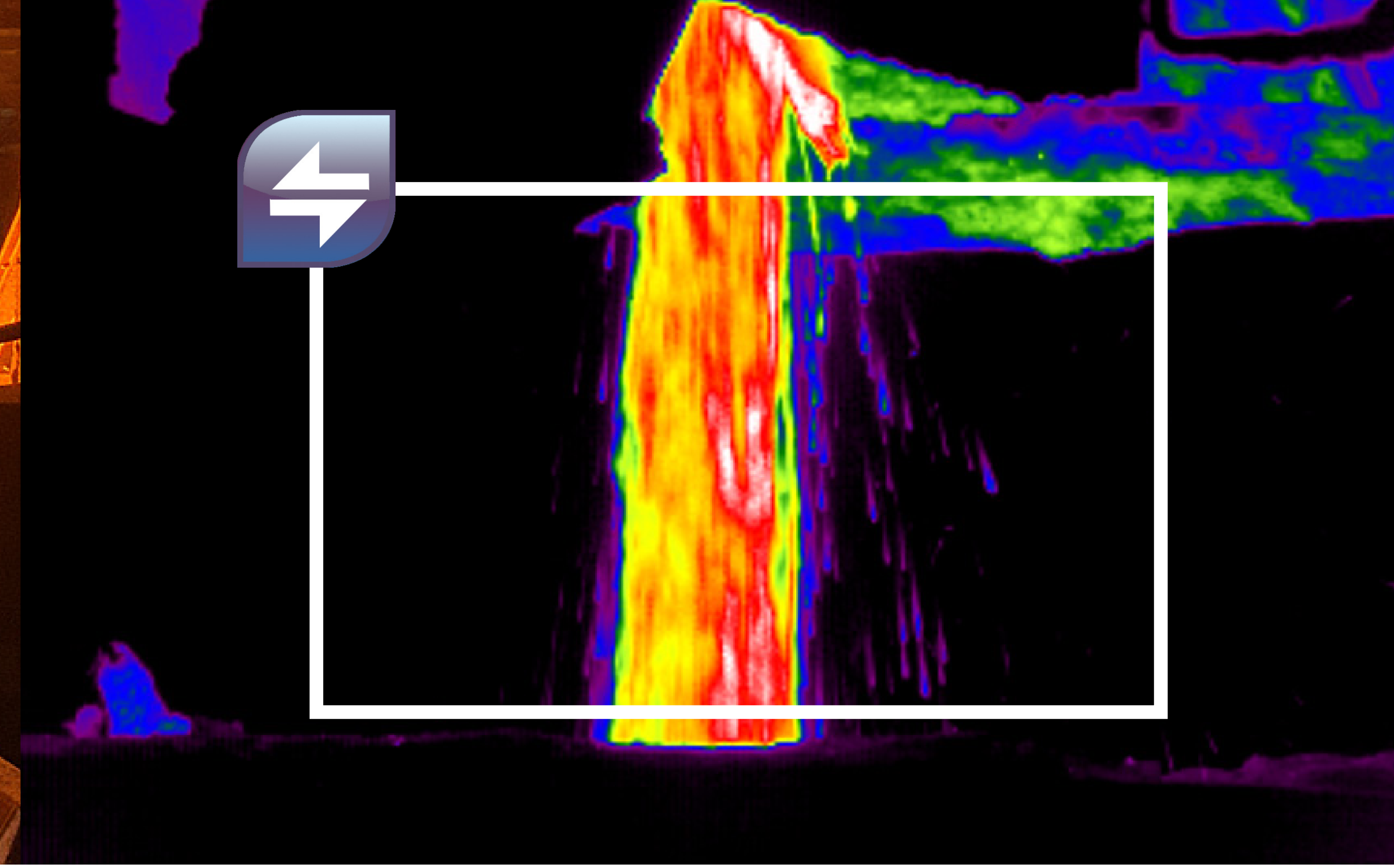
When molten steel is separated from the impurities found in iron ore and scrap metal, a molten liquid melt of silicates and oxides – known as slag – is produced. This solidifies upon cooling, and needs to be removed, as its impurities degrade steel. For example, slag will pull phosphorous from iron and, if not removed, the phosphorus reverts back into the steel, lowering its quality.

The disadvantages of slag carryover in the EAF are exactly the same as those in the BOF: longer processing time, high inclusion formation and steel cleanliness challenges, difficulty in ladle desulphurisation, caster nozzle clogging, and ladle refractory wear.

Slag also causes substantial wear and tear on the vessels involved. Its removal can require huge effort and expense on the part of steel producers.

Molten steel is tapped from the EAF vessels into transfer ladles for further refinement of the steel and it is important to prevent slag carryover during this tapping process, by stopping when slag begins to exit along with the steel.

Fortunately, slag detection technologies are available to help manage it reliably and effectively.



SLAG DETECTION TECHNOLOGIES

Originally, slag carryover was monitored through visual observation, using a ceramic dart to reduce slag flow, and utilising a circular induction coil. Each of these methods has drawbacks for safety, reliability, and/or efficiency, however.

Thermal imaging cameras were introduced to improve the process two decades ago, and offer cost and repeatability benefits. Steel and slag have different emissivities, so a thermal image of the tapping stream, displayed in a control room, helps enable operators to recognise the change in brightness very easily and detect when slag begins to appear.

Early devices used in this application were long-wavelength thermal imagers with an 8-14 µm response. The results were good, as the emissivity between steel and slag is accentuated by the long wavelengths. However, there was still fume obscuration, and the optical materials used were not sufficiently durable for the harsh environment, requiring frequent protective window or lens replacements.

Mid-wavelength thermal imagers offered several new possibilities. A thermal imager working at a more narrow, 3.9 µm waveband can see through hot CO_2 and hot water vapour. This shorter waveband also enabled the use of more practical optical systems using, for example, sapphire protection windows which offer good transmission characteristics from ultraviolet to approximately 5.5 µm in the infrared alongside high durability and chemical resistance.

Hot water vapour or steam and hot CO_2 appear in large quantities in the atmosphere around the tapping stream, each having characteristic absorption lines at different wavelengths. When these lines are combined on the same graph, images from an infrared camera with a spectral response around 3.9 µm are much clearer than those of a camera with a spectral response of 8 to 14 µm.

DIGITALISATION IN DECARBONISATION

Digitally connected measurement solutions allow steel mills to monitor temperatures in real-time, offering an increasing level of automation within the steelmaking process.

This has significant benefits for steel plants, as the immediate feedback that is provided can help identify potential safety hazards before they escalate.

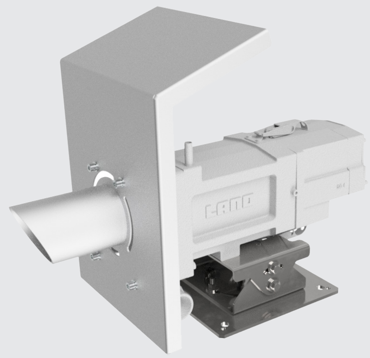
Additionally, connected pyrometers and cameras can generate the data needed to optimise steelmaking processes for greater efficiency and safety. Algorithms can adjust parameters to ensure operations stay within safe operating limits while maximising production.

This data also supports predictive maintenance by allowing analysis that helps understand when equipment may fail or degrade to dangerous levels. This helps prevent unexpected breakdowns and reduce the risk of process mishaps.

Digitalisation also supports decarbonisation through a more efficient process, helping to to save energy, control and optimise production, increase quality, and reduce the presence of harmful emissions.

Designed to operate in the harsh environments found in steel production, AMETEK Land's dedicated solutions for non-contact temperature measurements provide the Industry 4.0 and 5.0 connectivity required for a safer, more sustainable process that supports higher quality and lower costs.

SDS – SLAG DETECTION SYSTEM



The Slag Detection System (SDS) delivers improved yields, higher-quality steel and reduces costly downstream processing.

BENEFITS

- Fully automatic operation
- Lower slag content for improved steel quality
- Reduced downstream processing and material costs
- Accurate, rapid and repeatable detection with advanced software

INDUSTRIES

- Steel

APPLICATIONS

- Iron to Steel – Basic Oxygen Furnace
- Iron to Steel – Electric Arc Furnace – Tap
- Iron to Steel – SDS

TEMPERATURE RANGE

500 - 1800 °C / 932 - 3272 °F

A specially designed solution, the Slag Detection System (SDS), leverages the capabilities of mid-wavelength thermal imaging to help deliver improved yields, higher-quality steel, and reduce costly downstream processing for EAF steelmaking operations. It is specially designed to withstand the harsh conditions of continuous operation in a steel plant, with minimal maintenance requirements.

The AMETEK Land SDS has an industrial thermal imaging sensor, housed in a rugged, water-cooled and air-purged enclosure, that continuously views the tapping area. As the tap begins, dedicated software automatically records it, producing a log and graph of the relevant steel and slag data.

The high-resolution MWIR-640-SDS thermal imaging camera detects the transition between steel and slag, reducing "blackouts" caused by smoke and fumes. Real-time data enables the operator to make informed decisions about the tapping process.

When the slag reaches a pre-determined level, an alarm is generated to stop the tap. Full access to the tapping data is available to the operator for quality control purposes. By warning the operator in a dependable, repeatable and timely manner to stop the tap before slag is carried over, the SDS improves production yields and ensures a lower slag content, improving the steel's quality. This also reduces energy costs further along the process and lowers the overall maintenance on the furnace vessel.

Using an SDS has been shown to improve operator response time and consistency at the end of each tap. This results in a typical reduction in slag depths of up to 25 per cent, compared to traditional methods for monitoring slag.

The MWIR-640-SDS camera has a resolution of almost 300,000 individually calibrated temperature measurement points, providing much greater detail in the image. Combined with the clarity of view through the smoke, this offers a much-improved performance compared with other cameras.

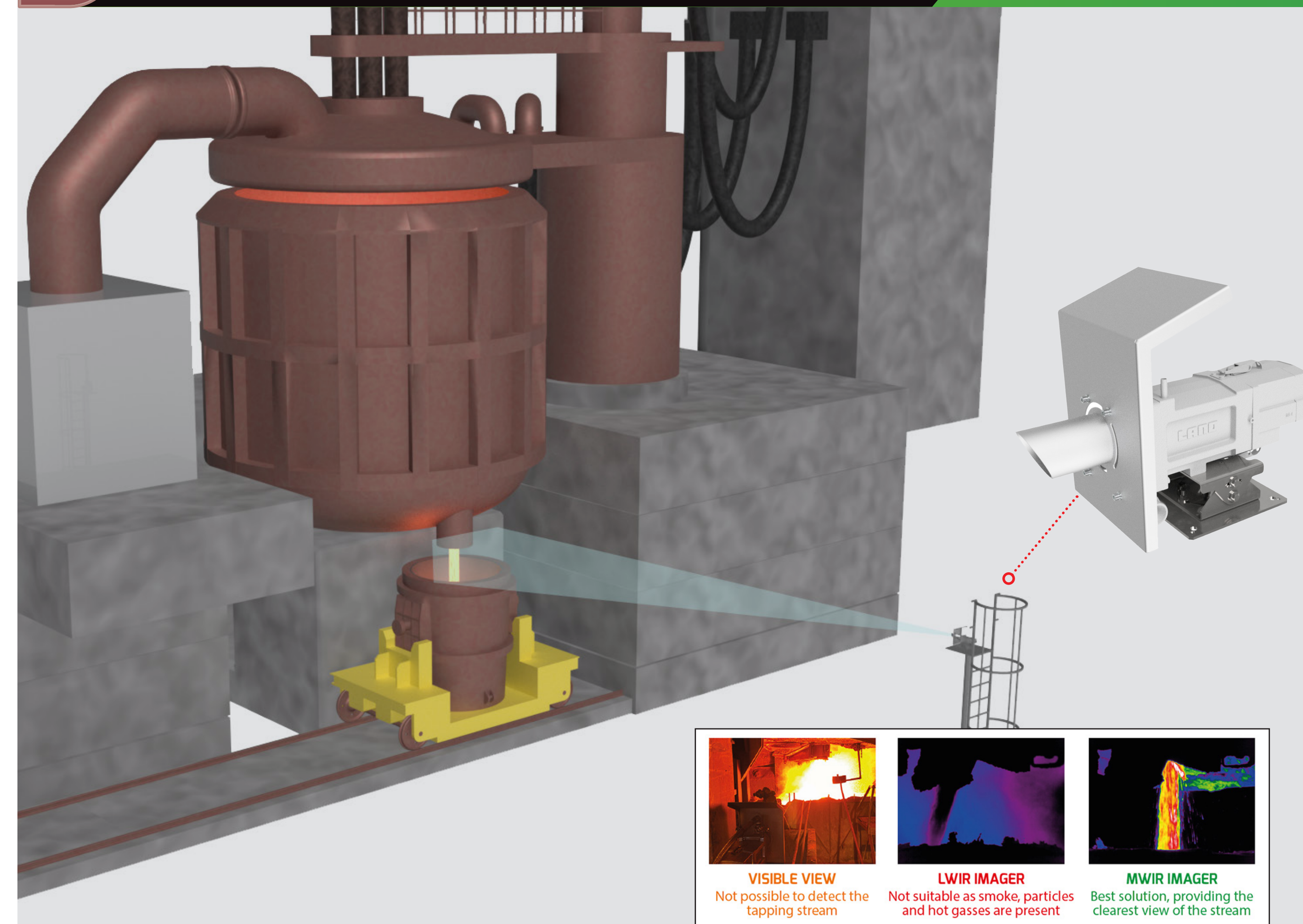
In addition, IMAGEPro-SDS application software provides improved images for the operator with the additional capability to automatically track the pouring stream within the field of view. When viewing the stream from an acute angle, its position will change during the different phases of the tap and the software accurately tracks any movement that may occur as the pour takes place, only measuring from the area identified as the stream. This reduces any errors caused by background heat sources in the field of view.

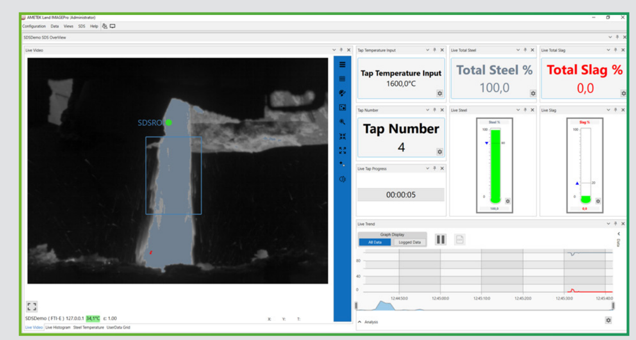
As well as detecting slag while tapping steel, the SDS can detect steel as it appears during the de-slagging operation. Depending on each location this can sometimes be achieved with the same camera but if not possible then a second camera may be required.

The improved image quality, with larger field of view, is a benefit to the operator for judging when the transfer ladle is full of liquid steel. This enables the tapping operation yield to be optimised and reduces the risk of molten metal spillage from overfilling.

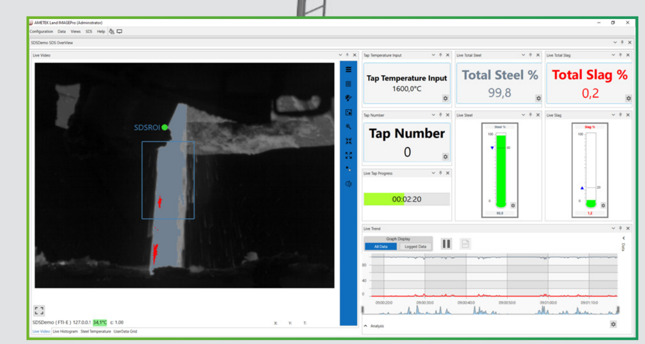
In locations where the camera cannot view the ladle freeboard, a second camera can be provided and the image included on the same operator's monitor using standard IMAGEPro software to provide regions of interest with alarms.

THE SLAG DETECTION SYSTEM — SDS

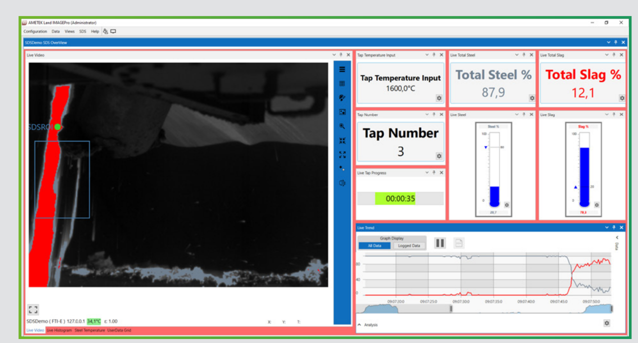




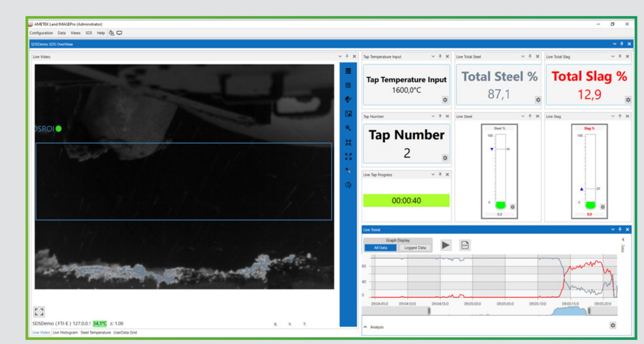
1. COMMENCES CONTENT MONITORING



2. MONITORS RISING SLAG CONTENT

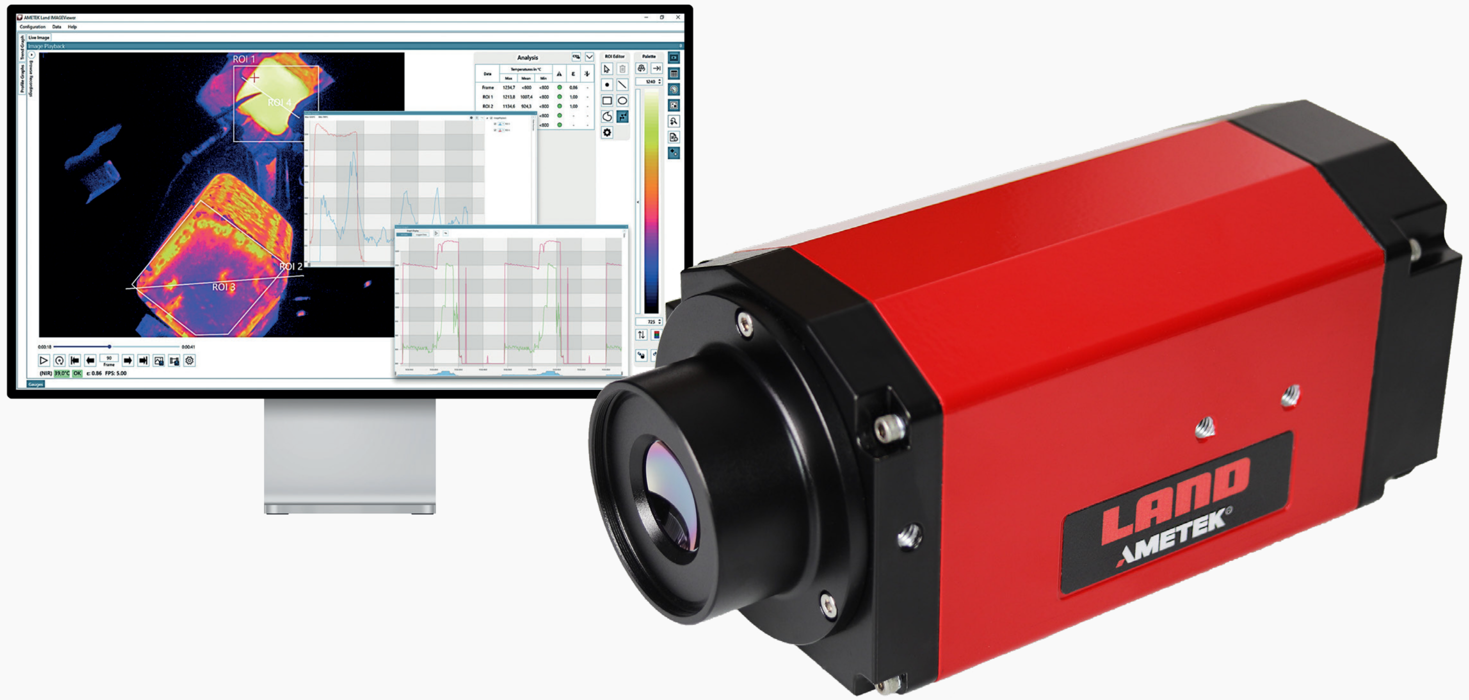


3. TRIGGERS ALARM AND STOPS TAP



4. CONFIRMS OVERALL TAP CONTENT

OTHER SOLUTIONS



The MWIR-640 390

A mid-wavelength thermal imager, the MWIR-640 390 is designed for a range of industrial applications including automation, process control, slag detection, secondary steel-making vessels, and melting operations.

Helping meet the demand for improved product quality and efficiency while delivering energy savings, predictive maintenance, and emissions reduction, the MWIR-640 390 provides reliable, robust, and real-time thermal imaging measurements and imagery.

It is designed for use in harsh industrial and environmental conditions, offering clear images through smoke or particulates in high-temperature processes through its advanced spectral filtering, which shows every surface structure detail in heat treatment applications.

With a pixel resolution of 640 x 480 and high thermal resolution, uniquely clear and detailed thermal images and videos are created at up to a 60 Hz frame rate. This unmatched image quality supports highly accurate process visualization and control.

A wide range of applications from melting to final processing are covered through two temperature measurement ranges – **500 °C to 1800 °C (932 to 3271 °F) and 300 °C to 1200 °C (572 to 2192 °F)**. This is supported by three lens options offering a choice of optical field of view, complete with motorised focus.

In addition, an integrated web server with multiple I/O options enables the camera to be used autonomously, or integrated easily into new or existing process control systems. Using a standard browser, the web server provides easy camera access, configuration, and remote control. The MWIR-640 390 utilises smart Industry 4.0 capabilities, bi-directional digital interfaces and an on-board I/O for real-time thermal imaging.

The NIR-2K

A high-precision thermal imager producing high-temperature measurements in a wide range of applications, the NIR-2K combines high accuracy with high-resolution measurement of temperature distributions to identify hot and cool spots for process optimization and the early detection of process deviations.

It provides a clear view of the process to the operator, while at the same time the process temperatures are precisely captured, documented, and also used for online process control.

AMETEK Land offers a variety of models covering temperature ranges from **600 to 1800 °C (1112 to 3272 °F)**, and a choice of different optics for a wide range of industrial processing applications

The NIR-2K enables a remote 24/7 view of the process and its temperatures online, with resolutions of up to 3 million fully radiometric calibrated camera pixels.

The LWIR-640

The LWIR-640 long-wavelength thermal imager builds on more than 20 years of thermal imaging experience, expanding the market-leading range of AMETEK Land temperature measurement solutions.

The available models offer a full temperature measurement range of **-20 to 1000 °C (-4 to 1832 °F)** in three ranges with a choice of different optics and lenses.

An integrated webserver with multiple I/O options enables the camera to be used autonomously or easily integrated into new or existing process control systems. The webserver provides easy camera access, control and setup, using a standard browser.

The LWIR-640 measures and streams live true-temperature images at up to 60 frames per second, providing high-precision temperature measurements and thermal profiles to continuously control, document, and visualise industrial processes.

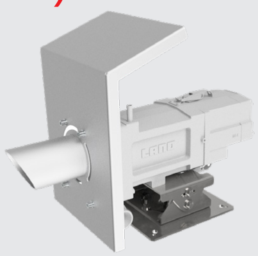
THE ROLE OF TEMPERATURE MEASUREMENT IN SUSTAINABLE STEELMAKING

AMECARE® PERFORMANCE SERVICES

Our global service centres provide after-sales services to ensure you get the best performance from your system. This includes technical support, certification, calibration, commissioning, repairs, servicing, preventative maintenance and training. Our highly trained technicians/engineers can also attend your site to cover planned maintenance schedules and repair emergency breakdowns.

Slag Detection System (SDS)

The Slag Detection System (SDS) delivers improved yields, higher-quality steel and reduces costly downstream processing. There are additional benefits in reduced ladle refractory wear.



FIXED THERMAL IMAGERS

MWIR-640 390

A smart mid-wavelength thermal imager providing wide temperature measurement range coverage, with a choice of different optics and lenses.

FIXED THERMAL IMAGERS

NIR-2K

A range of high-precision thermal imagers producing high-temperature and high resolution measurements in a wide range of applications.

FIXED THERMAL IMAGERS

LWIR-640

A long-wavelength smart thermal imager with integrated webserver and on-board I/O's.

FIXED THERMAL IMAGERS

FIND OUT MORE AT: WWW.AMETEK-LAND.COM

LAND AMETEK®

OneTemp pty ltd
measure | control | record
1300 768 887
www.onetemp.com.au